

Video game induced seizures

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Abstract

Fifteen patients who experienced epileptic seizures while playing video games are described together with a review of 20 cases in the English literature. Nine of the 15 cases and all but two of the reported cases experienced their first seizure while playing video games. Two thirds of patients had idiopathic generalised epilepsy and mainly reported generalised tonic clonic seizures, but some had typical absence seizures and myoclonic jerks while playing video games. In this series, 30% with idiopathic generalised epilepsy had juvenile myoclonic epilepsy. Overall, 70% of patients with idiopathic generalised epilepsy were photosensitive to intermittent photic stimulation and the mechanism of seizure provocation was probably similar to that of television induced seizures, although sensitivity to specific patterns was sometimes important. Two children had self induced video game seizures. Non-photoc factors such as excitement, fatigue, sleep deprivation, cognitive processing, and diurnal variation in susceptibility seemed to be important seizure precipitants, particularly in non-photosensitive patients. Twenty nine per cent of patients had partial (mainly occipital) video game associated seizures. Occipital spikes were common in the EEG of these patients. Photosensitivity to intermittent photic stimulation may have been important in two patients but in the others, who all played arcade video games, other mechanisms need to be considered. Video game associated seizures are a feature of several epileptic syndromes and differ in precipitants and appropriate management.

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Since the first description of "space invader epilepsy" in 1981¹ more than 20 cases of video game induced seizures have been reported in the English literature.²⁻¹⁴ Recent media reports have highlighted the risk of seizures precipitated by playing video games.¹⁵⁻¹⁷ Manufacturers now warn of the danger and the British Department of Trade and Industry has sponsored research into the subject.

It has been supposed that similar mechanisms that lead to television induced seizures cause video game induced seizures.^{18,19} Most patients with television induced seizures have idiopathic generalised epilepsy and easily demonstrable photosensitivity on intermittent

photic stimulation. Studies of television induced seizures, however, have concentrated mainly on patients known to be photosensitive,^{20,21} and patients in whom seizure precipitants are non-photoc are important may be under-represented.

We report 15 patients who had seizures while playing video games. We also review substantive cases reported in the English literature together with further information on some of them. The study aimed to ascertain whether video game induced seizures are an homogeneous seizure disorder, and whether video game induced seizures are analogous to television induced seizures, and to describe the important mechanisms of seizure precipitation.

Method

We reviewed all patients known to us over a period of seven years who had seizures while playing video games. Information on them was collected retrospectively from their medical notes, supplemented by interviews with patients and witnesses. Photosensitivity during EEG examinations was assessed with intermittent photic stimulation with a linear grid over the photic stimulator. A photoconvulsive response was defined as a generalised discharge of spike/multiple spike and wave complexes. A syndrome diagnosis based on the proposals of The International League Against Epilepsy was attempted in all cases.²²

Substantive cases of video game induced seizures in the English literature were reviewed. Further information was requested from the authors of cases published before the major series of Maeda *et al.*,⁹ especially concerning the subsequent clinical course and whether it had been possible to give a syndrome diagnosis.

Results

Fifteen patients with video game induced seizures are reported. Two were mentioned in a previous report.¹³ Unless otherwise stated, medical and family histories were not contributory and neurodevelopmental examination was normal. Identification of the particular video game associated with the seizures was impossible in many patients.

CASE 1

This female patient had a simple febrile convulsion at 3 years of age. Since the age of 14 she had typical absence seizures, myoclonic jerks, and infrequent generalised tonic clonic seizures (GTCSs) and was diagnosed as having juvenile myoclonic epilepsy. Her first GTCS occurred while playing monopoly, the

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second while playing a simulated game of tennis on a home video game, and the third while watching television. Subsequent GTCSs occurred after sleep deprivation without clear photic precipitants.

EEG examinations showed generalised spike/multiple spike and wave discharges, spontaneously, on hyperventilation, and on intermittent photic stimulation at 15 Hz. Her last EEG (at 22 years) no longer showed photosensitivity. Control was achieved with sodium valproate combined with carbamazepine.²³

CASE 2

At the age of 12 years, this boy had a GTCS. Myoclonic jerks were recognised a year later and juvenile myoclonic epilepsy was diagnosed. The GTCSs occurred mainly while playing a variety of home video games. No other precipitating factors were elicited.

An EEG showed generalised spike/multiple spike, and wave discharges spontaneously, on overbreathing, and on intermittent photic stimulation. Treatment with sodium valproate was successful.

CASE 3

This male patient developed typical absence seizures at the age of 14 years and myoclonic jerks and infrequent GTCSs two years later. Absences and particularly GTCSs occurred mainly while watching television and while playing various "Atari" home video games. Seizures were more likely after sleep deprivation. Excitement and frustration were powerful precipitating factors and television induced seizures only occurred while watching football and specifically when his team missed a scoring opportunity.

On EEG generalised spike/multiple spike and wave discharges were seen spontaneously and on overbreathing but not on intermittent photic stimulation. He was successfully treated with sodium valproate and clonazepam.

CASE 4

This 22 year old man had a single GTCS while playing a home video game. He had been deprived of sleep the previous night and had been playing the game for some hours. Questioning failed to show any history of previous absences or jerks but the GTCS had been preceded by a few jerks of his upper limbs.

An EEG, including overbreathing and intermittent photic stimulation, was normal. He has avoided video games and has remained seizure free without drug treatment.

CASE 5

This 21 year old man had a strong family history of epilepsy. His mother and sister had photosensitive epilepsy with typical absences and GTCSs. A maternal uncle died during a GTCS. Between the ages of 12 and 14 years he had three GTCSs. All occurred while playing home video games in the morning, although he usually played in the afternoon or

evening. He was not treated with anticonvulsants but stopped playing video games. He had one further GTCS walking to college on a sunny morning while under considerable emotional stress.

An EEG showed generalised spike/multiple spike and wave discharges on intermittent photic stimulation at flash frequencies of 12–25 and 50 Hz.

CASE 6

This 38 year old man had had typical absence seizures since age 10 years and GTCSs since age 20 years. Juvenile absence epilepsy was diagnosed. His GTCSs were precipitated by sleep deprivation and alcohol. He particularly noticed absences during tasks requiring concentration—for example, when playing a home video game that involved racing a car around a circuit. Absences often occurred at the most testing parts of the game causing him to crash.

Six EEGs showed generalised 3 Hz spike and wave discharges without photosensitivity. A combination of lamotrigine and sodium valproate controlled the seizures.

CASE 7

This 11 year old boy often played home video games without incident. While playing "Super Mario Bros" in an arcade he felt "dizzy" with a sensation of his head falling backwards. One to two minutes later he had a short GTCS. No other precipitating factors were identified.

His EEG was normal apart from a few bursts of generalised sharp theta waves consistent with idiopathic generalised epilepsy. There was no photoconvulsive response to intermittent photic stimulation. No treatment was started.

CASE 8

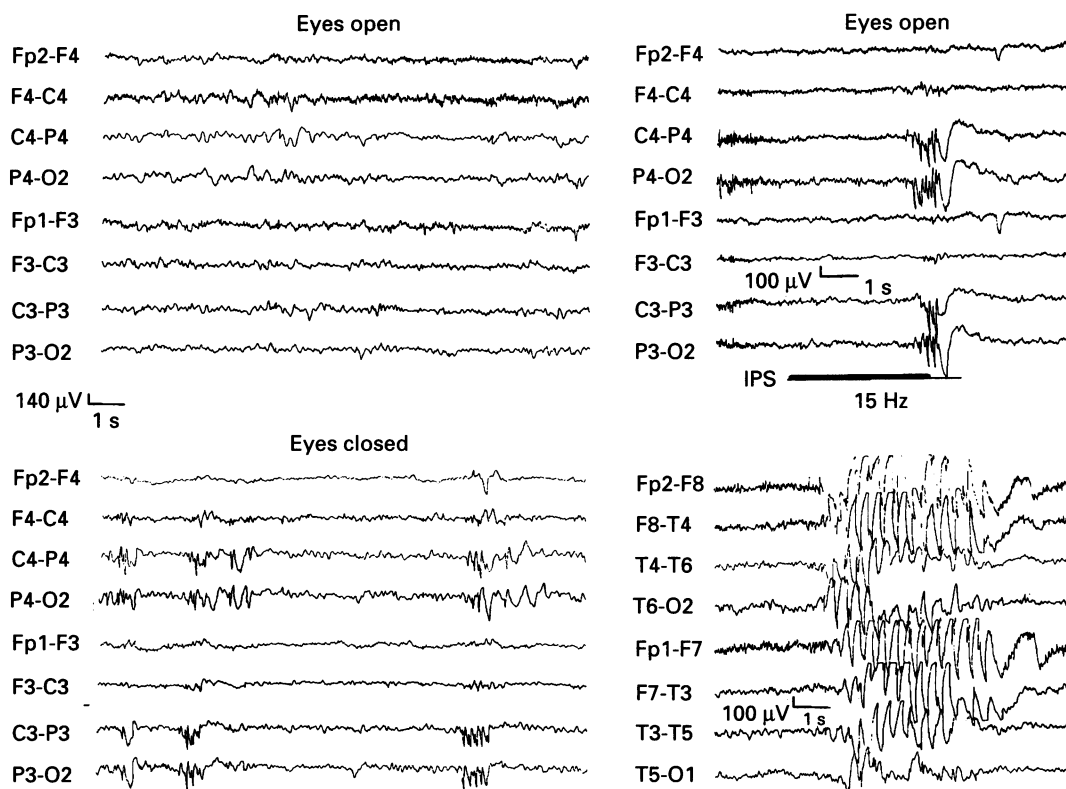
This 11 year old girl had a GTCS that occurred while changing television channels. Over the previous year she had had typical absences and myoclonic jerks that she found pleasurable and induced by rapidly changing television channels, particularly when emotionally upset. When this behaviour was frustrated by a new television set she induced absences, jerks, and occasional GTCSs by rapidly switching between games on a home video game.

An EEG examination showed generalised spike/multiple spike and wave discharges spontaneously with the eyes closed (but not on eye closure) and on intermittent photic stimulation. Sodium valproate suppressed her seizures.

CASE 9

This 12 year old boy has a sister with television induced absences and photosensitivity to intermittent photic stimulation. Absences started at the age of 2.5 years and GTCS at age 5 years. Seizures were precipitated by light or television and were so numerous as to require special schooling. Many were self induced by changing television channels. Recently his teachers reported that he had

Figure 1 EEG from case 10. Paroxysms of occipital spikes seen spontaneously only when the eyes are closed (top and bottom left). Paroxysms are induced by intermittent photic stimulation when the eyes are open (top right). A single generalised discharge, associated with mild impairment of consciousness, was seen on one occasion only (bottom right).



absences, often self induced, when playing home video games. Scenes involving flashes or oscillating images were particularly provocative.

EEG examinations showed spontaneous generalised discharges and pronounced photosensitivity with generalised spike/multiple spike and wave discharges over a wide range of flash frequencies as low as 1.5 Hz. Treatment with sodium valproate and carbamazepine was unsuccessful.

CASE 10

This 11 year old girl had had a number of febrile convulsions in early childhood then remained well until aged 5 years. Subsequently she had infrequent partial seizures during which consciousness was usually retained. She described obscuration of vision and elementary visual hallucinations of coloured light during the seizures, which lasted a few minutes and often occurred immediately after watching television. One attack occurred while toasting a bun in front of a fire and others occurred spontaneously. At 9 years of age she had had a seizure while playing a home video game. Additionally, occasional brief "absences" accompanied by eyelid fluttering were reported.

Five standard and two video EEG examinations (fig 1) showed bilateral paroxysms of occipital spikes and multiple spikes when the eyes were closed. Intermittent photic stimulation induced multiple spikes in the same regions (occipital photoconvulsive response) and was often associated with eyelid fluttering. There was no fixation off sensitivity. One record showed a generalised discharge of 3 Hz spike and slow waves with

mild impairment of consciousness. CT was normal. Treatment with sodium valproate was successful.

CASE 11

This 19 year old man had three short GTCSs all while playing the arcade video game "Captain Battle". No other precipitating factors were identified. An EEG showed photosensitivity on intermittent photic stimulation at 7–27 Hz. Subsequently he avoided video games and had no more seizures. Medication was not started.

CASE 12

This 10 year old boy had had two seizures one month apart at the age of 9 years. Both occurred while playing the video game "Michael Jackson" in an arcade. On both occasions initial ictal symptoms consisted of elementary visual hallucinations, lasting about 20 seconds, followed by a short GTCS.

An EEG showed occipital spikes (fig 2). There was no photoconvulsive response to intermittent photic stimulation. He avoided video games and had no more seizures. Medication was not started.

CASE 13

This 14 year old boy experienced a single seizure after playing a video game in an arcade for 10 minutes. Initial visual symptoms (scotomata and elementary visual hallucinations) lasting for about 60 seconds were followed by a GTCS. An EEG showed a right occipital spike focus. There was no photoconvulsive response to intermittent photic stimulation. No medication was started but he avoided video games and had no more seizures.

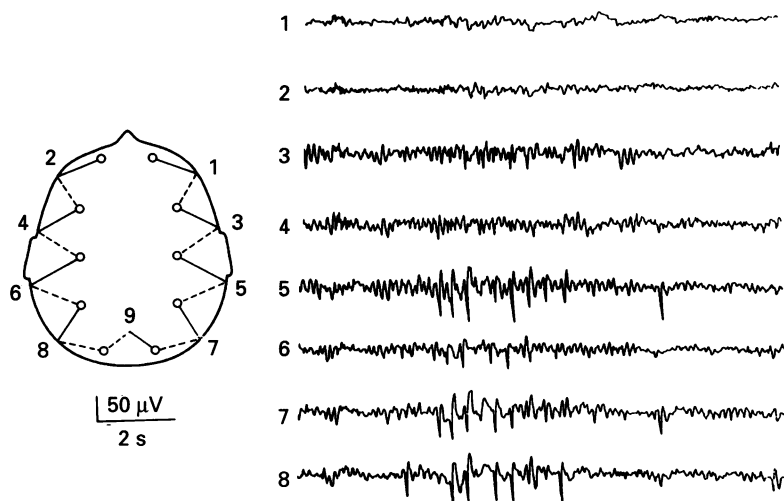


Figure 2 EEG from case 12.

CASE 14

This 14 year old boy had a seizure whilst playing "Asterix against the Romans" in an arcade. Initial visual symptoms (elementary visual hallucinations followed by scotomata) were followed by a GTCS. An EEG showed a right temporo-occipital spike focus. There was no photoconvulsive response to intermittent photic stimulation. Medication was not started but he avoided video games and had no further seizures.

CASE 15

This 15 year old boy with no history or family history of note had a single seizure while playing an arcade video game. Initial visual symptoms (foggy vision and restriction of both

visual fields) were followed after about 40 seconds by a GTCS. An EEG showed a right temporo-occipital spike focus. There was no photoconvulsive response to intermittent photic stimulation. No medication was started but he avoided video games and had no more seizures.

There were 20 patients with video game induced seizures in 12 substantive case reports in the English literature. These, supplemented with further information (see acknowledgements), are summarised in the table. We excluded reports which were insufficiently detailed.^{12 13 14}

Combining the data from our 15 cases with the 20 described in the literature, the median age at which video game induced seizures were first experienced was 13 (range 4–35) years with a male:female ratio of almost 4:1. In 15 patients seizures occurred while playing home video games (in one a hand held version) and in 12 patients whilst playing arcade video games. In eight patients this information was not known. No patient with mixed home and arcade video game induced seizures was found. In only one family was more than one sibling affected by video game induced seizures.¹⁰ In 19 patients all seizures were provoked by video games (in 11 cases only a single seizure had occurred). Nine patients had also experienced other light induced seizures. In contrast to our patients, none of the previous cases had television induced seizures. Twelve out of the 35 patients had also experienced spontaneous seizures.

Fourteen patients (70%) in the literature and 10 of our cases (67%) had forms of idio-

Summary of substantive reports of video game induced seizures in the literature

Author	Sex	Age (y)	Video game induced seizures	Television induced seizures	Other photic seizures	Spontaneous seizures
Rushton ¹	M	17	+ (GTCS preceded by "temporal lobe type aura") + + (2 "auras") + + (3 GTCSs)	—	—	—
Jeavons <i>et al</i> ²	M	14	+ + (3 GTCSs)	—	—	—
Daneshmend and Campbell ³	F	17	+ (GTCSs)	—	—	—
Dalquist <i>et al</i> ⁴	M	15	+ (absence status ?) + (GTCS)	—	+ (GTCS)	+ *
Helfgott and Meister ⁵	M	8	+ ("unobserved fall")	—	—	+ (GTCS)
Glista <i>et al</i> ⁶	M	14	+ + (2 GTCSs)	—	—	+ (GTCS)
	M	15	+ (GTCS with preceding visual symptoms) + (2 GTCSs)	—	—	—
De Marco and Ghersini ⁷	M	8	+ + (3 GTCSs with preceding visual symptoms) + ("felt strange" followed by GTCS)	—	—	—
Hart ⁸	F	13	+ (scotomata followed by LOC) + + (headaches†) + (headache, pallor, and jaw tremble) + (GTCS)	—	+ (GTCS)	+ (GTCS) + (headaches†) + + (headaches†)
Maeda <i>et al</i> ⁹	M	6	+ (scotomata followed by LOC) + + (headaches†) + (headache, pallor, and jaw tremble) + (GTCS)	—	—	—
	F	10	+ (headache, pallor, and jaw tremble) + (GTCS)	—	+ (GTCS)	—
	M	12	+ (adversive seizure) + + (GTCS)	—	—	—
	M	4	+ + (GTCS)	—	—	—
	M	11	+ + (GTCS)	—	—	—
	M	13	+ (GTCS)	—	—	+ (GTCS)
	M	9	+ (GTCS)	—	—	+ (GTCS)
Cook and Hoskins ¹⁰	M	11	+ (GTCS) and + (funny tingling) + (GTCS)	—	—	+ ("funny tingling")
Thompson ¹¹	M	17	+ (GTCS)	—	—	—
	M	15	+ (lightheaded followed by GTCS)	—	—	—

*Nature of this seizure unclear. †Considered ictal. The designation of idiopathic generalised epilepsy or partial seizure disorder is our interpretation of the available data; age refers to first video game induced seizure; + = one seizure of this type experienced; ++ = more than one seizure of this type experienced; — = this type of seizure not experienced; GTCS = generalised tonic clonic seizure; SSW = spike/multiple spike and slow wave discharge.

pathic generalised epilepsy or single GTCSs with no clinical or EEG evidence of focal onset. Thirteen of the previously reported cases had video game induced GTCS. One patient reported "feeling strange" before the GTCS⁸ and another felt "light headed."¹¹ These may have been absence seizures. Another patient experienced symptoms suggestive of absence status after playing a video game.⁴ Four of our patients had video game induced absences and one had video game induced myoclonic jerks. Ten patients (76%) with idiopathic generalised epilepsy reported in the literature and six of our cases (60%) were photosensitive on intermittent photic stimulation.

Five patients (25%) in the literature and five of our cases (33%) had video game induced partial seizures. Three of the reported cases^{6,7,9} and all of ours had elementary visual symptoms usually preceding GTCSs. Interictal EEG recordings in six of these cases showed occipital or temporo-occipital spikes/multiple spikes. One patient in the literature was photosensitive on intermittent photic stimulation⁹ and one of our cases (case 10) had an occipital photoconvulsive response.

Discussion

The median age at first video game induced seizure is similar to that seen in photosensitive epilepsies in general and television induced seizures in particular.^{18,19} There is a 4:1 male predominance in video game induced seizures, despite two thirds of photosensitive patients being female.¹⁹ This has been attributed to a greater number of boys playing

video games than girls,⁹ but a survey of video game playing in American schoolchildren found that 66% of girls and 90% of boys played home video games for at least one to two hours a week.²⁴ Factors other than photosensitivity may therefore contribute to the male excess.

Patients with video game induced epileptic seizures fall into at least three main groups: (a) Those with idiopathic generalised epilepsy and photosensitivity; (b) those with idiopathic generalised epilepsy without photosensitivity; (c) those with partial (occipital) seizures.

IDIOPATHIC GENERALISED EPILEPSIES

Most patients with video game induced seizures had forms of idiopathic generalised epilepsy. Syndromic diagnosis of the idiopathic generalised epilepsy was not provided for any of the cases in the literature. One report was consistent with juvenile myoclonic epilepsy⁴ and this was the diagnosis in three of our cases (30%), compatible with the high prevalence of photosensitivity in this syndrome.²⁵ Another patient had juvenile absence epilepsy.

In the reported cases GTCSs predominate. Our series is the first clearly to describe video game induced absences and myoclonic jerks, although they have been described in patients with television induced seizures^{20,21,26,27} and are commonly precipitated in photosensitive subjects by intermittent photic stimulation.

PHOTOSENSITIVITY

Most patients with idiopathic generalised epilepsy and video game induced seizures are

EEG findings	Classification
Normal	Partial seizure disorder
Irregular SSW with inconstant focal features. Photoconvulsive response on intermittent photic stimulation (15–18 Hz) and on playing video games	Idiopathic generalised epilepsy
Photoconvulsive response on intermittent photic stimulation (15–21 Hz)	Idiopathic generalised epilepsy
Photoconvulsive response on intermittent photic stimulation (15 and 20 Hz)	Idiopathic generalised epilepsy, probably juvenile myoclonic epilepsy
Spontaneous left focal SSW	Probably idiopathic generalised epilepsy
Spontaneous SSW. Intermittent photic stimulation negative	Idiopathic generalised epilepsy
Normal	Partial seizure disorder
Photoconvulsive response on intermittent photic stimulation (20–22 Hz)	Idiopathic generalised epilepsy
Left occipital spike focus. Intermittent photic stimulation negative	Partial seizure disorder
Photoconvulsive response on intermittent photic stimulation >8 Hz	Idiopathic generalised epilepsy
Occipital slow wave. Photoconvulsive response on intermittent photic stimulation (3–30 Hz), pattern and video game testing	Partial seizure disorder
Occipital slow wave. Photoconvulsive response on intermittent photic stimulation (12–30 Hz), pattern and video game testing	Classification uncertain
Photoconvulsive response on video game testing only	Single GTCS
Photoconvulsive response on video game testing only	Partial seizure disorder?
Photoconvulsive response on intermittent photic stimulation (15–30 Hz).	Probable idiopathic generalised epilepsy
Occipital spike on pattern testing	
Photoconvulsive response on intermittent photic stimulation (12–30 Hz)	Idiopathic generalised epilepsy
Photoconvulsive response on intermittent photic stimulation (3–30 Hz)	Idiopathic generalised epilepsy
Photoconvulsive response on intermittent photic stimulation (wide range of frequencies)	Idiopathic generalised epilepsy
Photoconvulsive response on idiopathic generalised epilepsy (11–20 Hz)	Idiopathic generalised epilepsy
Normal	Single GTCS

photosensitive to intermittent photic stimulation and may also experience television induced seizures. Television induced seizures are provoked by the 50 Hz flicker from the mains or by the 25 Hz raster pattern of the picture.^{18,19} Similar mechanisms are likely to be involved in provoking video game induced seizures in photosensitive patients who play home video games on television screens. Self induction of seizures—for example, by rapidly changing television channels—has been described in photosensitive patients,^{19,21} but cases 7 and 8 are the first reports of similar behaviour with video games.

Some patients who are photosensitive to intermittent photic stimulation are also sensitive to patterns, particularly oscillating black and white stripes,^{28,29} and seizure provocation by patterns may be clinically dominant.^{30,31} Maeda *et al* provoked a photoconvulsive response in patients more easily by showing certain scenes in video games than by intermittent photic stimulation.⁹ Such provocative patterns may be more frequent and persistent in video games than in television pictures.

NON-PHOTIC FACTORS

A significant minority of patients with idiopathic generalised epilepsy and video game induced seizures were not photosensitive to intermittent photic stimulation, in contrast to most reports of television induced seizures.^{20,21} Our methods of testing maximise detection of photosensitivity³² and it is therefore unlikely that deficiencies in methodology explain this.

Several non-photoc factors may have a role in precipitating video game induced seizures. Playing video games evokes a metabolic response equivalent to light exercise,³³ probably reflecting emotional excitement. Excitement was an important mechanism in provoking seizures in at least one patient (case 3). Sleep deprivation and fatigue caused by prolonged playing were important in case 4 and were also mentioned in other reports.^{5,8,10} The increased susceptibility to seizures for the few hours after wakening seemed relevant in case 5 (who was also photosensitive). In patient 6 cognitive functions were responsible for provoking video game induced absences. Such mechanisms may be responsible for other cases of game playing seizures.³⁴

PARTIAL EPILEPSIES

There was a high proportion of video game induced seizures of partial, usually occipital, onset. The mechanisms provoking occipital video game induced seizures are not clear. Photosensitive mechanisms may sometimes be involved, as in case 10. In this case the lack of fixation off sensitivity, the occurrence of an occipital photoconvulsive response, and the morphology of the spikes distinguish the condition from benign childhood epilepsy with occipital paroxysms.³⁵ Most patients with video game induced occipital seizures were not photosensitive. Partial video game induced seizures were characteristically provoked by playing arcade video games. The contrast in illumination between the screen and surroundings may be an important

provocative factor. Fixation off sensitivity, which is sometimes enhanced by previous prolonged fixation,³⁶ may be involved in some patients. At the time this was not routinely tested for and, therefore, we cannot comment on its prevalence in cases 12–15.

Television-induced partial seizures may previously have been under-recognised and possibly constitute up to one third of television induced seizures,^{14,37} similar to the prevalence of partial epilepsy in this series of video game induced seizures. Patients with occipital television induced seizures and video game induced seizures may have a form of benign partial epilepsy.¹⁴

OTHER SEIZURES

The series by Maeda *et al* is unusual for the frequency at which headaches are described.⁹ It is not clear if these were associated with generalised or partial seizures. The differentiation between migrainous headaches and occipital seizures has been recently reviewed.³⁸

Relation between playing video games and induction of seizures

A problem in all studies of reflex epilepsies is establishing a causal relation between seizures and their supposed precipitant. Where repeated seizures occur that are all or mainly associated with the precipitant then the relation is clear (cases 2, 3, 5, 8, 9, 11, and 12). Additionally in patients who are photosensitive the occurrence of a seizure while playing video games is likely to be causally linked (cases 1 and 10). Where patients have frequent spontaneous seizures, their occurrence while playing video games is likely to arise by chance. None of our patients clearly come into this category, although it is possible that playing video games merely brought the occurrence of absences to the attention of patient 6. This is unlikely, however, as it was only during “difficult” parts of the game that he was liable to crash. It may be argued that in patients who had single seizures and were not photosensitive on intermittent partial seizures (cases 4 and 7), the association with playing video games is likely to be fortuitous and other factors such as sleep deprivation were the sole precipitates. We consider that a more likely explanation is that the accumulation of a number of factors, some unrelated to video games (for example, sleep deprivation) and others that are related (for example, fatigue, excitement, frustration), is probably important.

MANAGEMENT

In patients who had a single GTCS the association with playing a video game may have been fortuitous, and the possibility of non-epileptic events should always be considered. Advice depends on the type of video game induced seizures. In highly photosensitive patients, that which is given to patients with television induced seizures is probably appropriate¹⁸ and may allow some to continue playing. In others avoidance of video games altogether or at least specific games may be

necessary. The importance of non-photoc factors should be stressed to both groups. At present it is not clear how those with occipital video game induced seizures should be advised but arcade video games may need to be avoided. Play should be stopped if minor events suggestive of absences, jerks, or visual phenomena occur, as this may prevent progression to GTCS.

Drug treatment may not always be necessary. Sodium valproate is the drug of choice in those with idiopathic generalised epilepsy. In those with occipital seizures the treatment of choice is not clear.

In conclusion, the term "video game seizures" encompasses a diverse group of reflex epilepsies, and may occur in several distinct idiopathic generalised epilepsy syndromes. An important finding of this study is the precipitation by video games of partial seizures arising from the occipital lobe. Video game induced seizures are not synonymous with television induced seizures, and the first often have non-photoc seizure precipitants. Further studies of the mechanisms provoking video game induced seizures should increase our understanding of the mechanisms underlying seizure precipitation in general.

Addendum

Since submitting this paper, we have seen a further three patients with video game induced seizures. None had generalised photoconvulsive responses on intermittent photic stimulation. One 22 year old man had a GTCS while playing a video game on a domestic television, and a further GTCS preceded by a prolonged absence while playing a video game on a laptop computer. Hunger, thirst, fatigue, and mild photosensitivity (transient sharp activity following intermittent photic stimulation) may have been compounding precipitating factors. Another boy, aged 13, had recurrent episodes of obscuration of vision and visual hallucinations of coloured lights and a single GTCS, preceded by these symptoms, while playing a handheld video game. EEG showed an occipital spike focus. The final patient had recurrent nocturnal GTCS with postictal headache and vomiting. At age 14, he had a single diurnal GTCS, preceded by visual hallucinations of coloured balls of light, while playing a video game on a domestic television in a well lit room. EEG has been consistently normal and he has been free of seizures for four years and is now off treatment.

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- 1 Rushton DN. Space Invader epilepsy. *Lancet* 1981;1:501.
- 2 Jeavons PM, Barton ME, Bishop A. Seizures and handheld space-invaders. *Lancet* 1981;2:758.
- 3 Daneshmend TK, Campbell MJ. Dark Warrior epilepsy. *BMJ* 1982;2:1751-2.
- 4 Dahlquist NR, Mellinger JF, Klass DW. Hazard of video games in patients with light-sensitive epilepsy. *JAMA*

- 1983;249:776-7.
- 5 Helfgott PC, Meister J. Seizure apparently triggered by video games. *JAMA* 1983;250:1273.
- 6 Glista GG, Frank HG, Tracy FW. Video games and seizures. *Arch Neurol* 1983;40:558.
- 7 De Marco P, Ghersini L. Videogames and epilepsy. *Dev Med Child Neurol* 1985;27:519-21.
- 8 Hart EJ. Nintendo epilepsy. *N Engl J Med* 1990;322:1473.
- 9 Maeda Y, Kurokawa T, Sakamoto K, Kitamoto I, Kohji U, Tashima S. Electroclinical study of video-game epilepsy. *Dev Med Child Neurol* 1990;32:493-500.
- 10 Cook TL, Hoskins M. Video game seizures: technical considerations. *J Electrophysiol Technol* 1992;18:175-84.
- 11 Thompson KJ. Video game induced generalised epileptic convulsion. *NZ Med J* 1993;106:88.
- 12 Ferry PC, Banner W, Wolf RA. *Seizure disorders in children*. Philadelphia: Lippincott, 1986:42-3.
- 13 Panayiotopoulos CP, Obeid T, Tahan AR. Juvenile myoclonic epilepsy: a five year prospective study. *Epilepsia* 1994;35:285-96.
- 14 Michelucci R, Tassinari CA. Television-induced occipital seizures. In: Andermann F, Beaumanoir A, Mira L, Roger J, Tassinari CA, eds. *Occipital seizures and epilepsies in children*. London: John Libbey, 1993:141-4.
- 15 Anon. Computer games "induced seizures". *The Times* 6 January 1993:2.
- 16 Hodgkinson L. Playing it safe. *Sunday Times* (section 5), 10 January 1993:5.
- 17 Anon. One eye on the screen. *Independent* 19 January 1993:8.
- 18 Wilkins A, Lindsay J. Common forms of reflex epilepsy: physiological mechanisms and techniques for treatment. In: Pedley TA, Meldrum BS, eds. *Recent advances in epilepsy* 2. Edinburgh: Churchill Livingstone, 1985: 239-71.
- 19 Binnie CD, Jeavons PM. Photosensitive epilepsies. In: Roger J, Bureau M, Dravet C, Dreifuss FE, Perret A, Wolf P, eds. *Epileptic syndromes in childhood and adolescence*. London: John Libbey, 1992:299-305.
- 20 Jeavons PM, Harding GFA. *Photosensitive epilepsy*. London: Heinemann, 1975.
- 21 Kasteleijn-Nolst Trenite DGA. Photosensitivity in epilepsy, electrophysiological and clinical correlates. *Neurol Scand* 1989;80(suppl 125).
- 22 Commission on Classification and Terminology of the International League Against Epilepsy. Proposal for revised classification of epilepsies and epileptic syndromes. *Epilepsia* 1989;30:389-99.
- 23 Panayiotopoulos CP. Photosensitive epilepsy with particular reference to occipital spikes induced by intermittent photic stimulation. PhD thesis, Aston University, Birmingham, 1972.
- 24 Funk JB. Re-evaluating the impact of video games. *Clin Pediatrics* 1993;32:86-90.
- 25 Grünwald RA, Panayiotopoulos CP. Juvenile myoclonic epilepsy. A review. *Arch Neurol* 1993;50:594-8.
- 26 Kasteleijn-Nolst Trenite DGA, Binnie CD, Meinardi H. Photosensitive patients: symptoms and signs during intermittent photic stimulation and their relation to seizures in daily life. *J Neurol Neurosurg Psychiatry* 1987;50:1546-9.
- 27 Binnie CD, Darby CE, Kasteleijn-Nolst Trenite DGA, Wilkins AJ. Photosensitive epilepsy: clinical features. In: Beaumanoir A, Gastaut H, Naquet R, eds. *Reflex seizures and reflex epilepsies*. Geneva: Medicine and Hygiene, 1989:163-70.
- 28 Stefansson SB, Darby CE, Wilkins AJ, et al. Television epilepsy and pattern sensitivity. *BMJ* 1977;2:88-90.
- 29 Wilkins AJ, Darby CE, Binnie CD. Neurophysiological aspects of pattern-sensitive epilepsy. *Brain* 1979;102: 1-25.
- 30 Wilkins AJ, Andermann F, Ives J. Stripes, complex cells and seizures. An attempt to determine the locus and nature of the trigger mechanism in pattern-sensitive epilepsy. *Brain* 1975;98:365-80.
- 31 Panayiotopoulos CP. Self-induced pattern-sensitive epilepsy. *Arch Neurol* 1979;36:48-50.
- 32 Jeavons PM, Harding GFA, Panayiotopoulos CP, Drasdo N. The effect of geometric patterns combined with intermittent photic stimulation in photosensitive epilepsy. *Electroencephalogr Clin Neurophysiol* 1972;33:221-4.
- 33 Segal KR, Dietz HD. Physiological response to playing a video game. *Am J Dis Child* 1991;145:1034-6.
- 34 Goossens LAZ, Andermann F, Andermann E, Remillard GM. Reflex seizures induced by calculation, card or board games, and spatial tasks: a review of 25 patients and delineation of the epileptic syndrome. *Neurology* 1990;40:1171-6.
- 35 Panayiotopoulos CP. Benign childhood epilepsy with occipital paroxysms. In: Andermann F, Beaumanoir A, Mira L, Roger J, Tassinari CA, eds. *Occipital seizures and epilepsies in children*. London: John Libbey, 1993:151-64.
- 36 Panayiotopoulos CP. Fixation-off-sensitive epilepsies. In: Beaumanoir A, Gastaut H, Naquet R, eds. *Reflex seizures and reflex epilepsies*. Geneva: Medicine and Hygiene, 1989:203-17.
- 37 Tassinari CA, Rubboli G, Plasmati R, et al. Television induced epilepsy with occipital seizures, a variety of idiopathic partial occipital epilepsy. In: Beaumanoir A, Gastaut H, Naquet R, eds. *Reflex seizures and reflex epilepsies*. Geneva: Medicine and Hygiene, 1989:241-3.
- 38 Panayiotopoulos CP. Difficulties in differentiating migraine and epilepsy based on clinical and EEG findings. In: Andermann F, Lugaresi J, eds. *Migraine and epilepsy*. New York: Raven Press, 1987:31-46.